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Lake Britton
Shasta County, California

(U.S.) National Eutrophication Survey, Corvallis, OR

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U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

REPORT
ON
LAKE BRITTON
SHASTA COUNTY
CALIFORNIA
EPA REGION IX
WORKING PAPER No. 741

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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REPORT
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WITH THE COOPERATION OF THE

CALIFORNIA STATE WATER RESOURCES CONTROL BOARD

AND THE

CALIFORNIA NATIONAL GUARD

JUNE, 1978

CONTENTS

	Page
Foreword	ii
List of California Study Lakes	iv
Lake and Drainage Area Map	v,vi
Sections	
I. Conclusions	1
II. Reservoir and Drainage Basin Characteristics	4
III. Water Quality Summary	5
IV. Nutrient Loadings	10
V. Literature Reviewed	16
VI. Appendices	17

FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentration (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGEMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U.S. Environmental Protection Agency) expresses sincere appreciation to the California State Water Resources Control Board and the nine Regional Water Quality Control Boards for professional involvement, to the California National Guard for conducting the tributary sampling phase of the Survey, and to those California wastewater treatment plant operators who voluntarily provided effluent samples and flow data.

The staff of the Division of Planning and Research of the State Water Resources Control Board provided invaluable lake documentation and counsel during the Survey, coordinated the reviews of the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

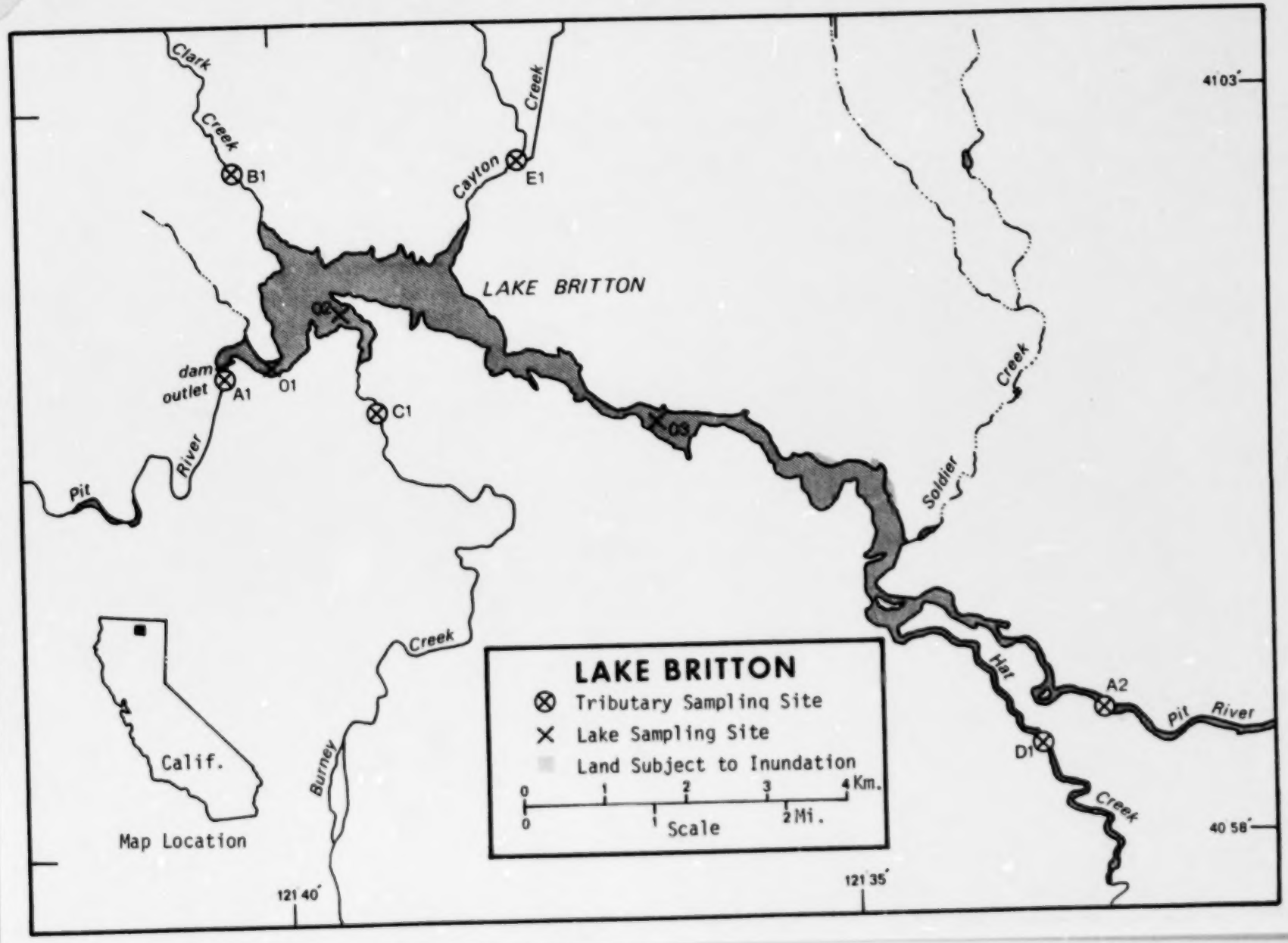
Major General Glen C. Ames, the Adjutant General of California, and Project Officer Second Lieutenant Terry L. Barrie, who directed the volunteer efforts of the California National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

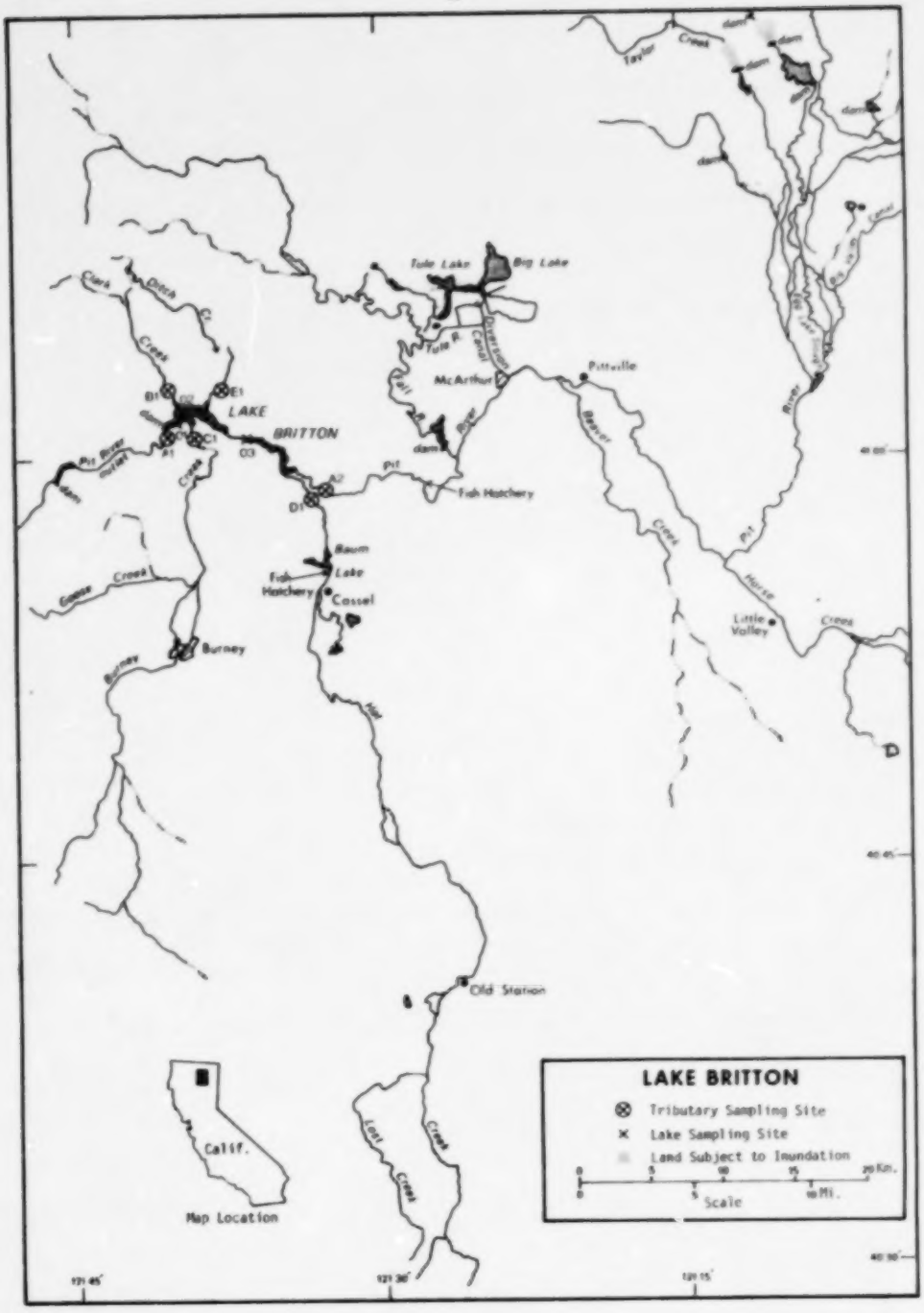
NATIONAL EUTROPHICATION SURVEY

STUDY RESERVOIRS

State of California

Name	County
Amador	Amador
Boca	Nevada
Britton	Shasta
Casitas	Ventura
Crowley	Mono
Don Pedro	Tuolumne
Elsinore	Riverside
Fallen Leaf	El Dorado
Hennessey	Napa
Henshaw	San Diego
Iron Gate	Siskiyou
Lopez	San Luis Obispo
Mary	Mono
Mendocino	Mendocino
Nicasio	Marin
Lower Otay	San Diego
Pillsbury	Lake
Santa Margarita	San Luis Obispo
Shasta	Shasta
Shaver	Fresno
Silver	Mono
Tahoe	El Dorado, Placer, CA; Carson City, Douglas, Washoe, NV
Tulloch	Calaveras, Tuolumne
Lower Twin	Mono
Upper Twin	Mono


Clark Creek
B1
Cayton Creek
E1
LAKE BRITTON
02
dam outlet
A1
01
C1
03
Pit River
Soldier Creek
Burney Creek
Hat Creek
A2
Pit River
D1
Creek
41 03'
40 58'
121 40'
121 35'
Calif.
Map Location
LAKE BRITTON
Tributary Sampling Site
Lake Sampling Site
Land Subject to Inundation
0 1 2 3 4 Km.
0 1 2 Mi.
Scale


Taylor Creek
dams
Tule Lake
Big Lake
Clark Creek
Ditch Cr.
Tule R.
Canal
McArthur
Pittville
Fall River
B1
B2
E1
LAKE
BRITTON
C1
C2
A1
A2
D1
D2
Pit River
dams
Fish Hatchery
Baum Lake
Fish Hatchery
Cassel
Goose Creek
Burney
Burney Creek
Hat
Beaver Creek
Pit River
Horse Creek
Little Valley
Old Station
Lost Creek
Calif.
Map Location
LAKE BRITTON
Tributary Sampling Site
Lake Sampling Site
Land Subject to Inundation
Scale
121 45'
121 30'
121 15'
40 45'
40 30'

LAKE BRITTON

STORET NO. 0603

I. CONCLUSIONS

A. Trophic Condition*:

Survey data indicate that Lake Britton is eutrophic. However, because this water body has a mean hydraulic retention time of only 6 days, it more closely resembles a slow-moving river, and the term over-enriched may be a more appropriate description. Lake Britton ranked eighteenth in overall trophic quality among the 24 California lakes and reservoirs sampled in 1975 when compared using a combination of six parameters**. Nineteen of the water bodies had less median total phosphorus and orthophosphorus, 18 had less median inorganic nitrogen, 12 had less mean chlorophyll a, and 19 had greater mean Secchi disc transparency. Some depression of dissolved oxygen with depth occurred at station 1 in July (minimum of 3.8 mg/l).

Survey limnologists noted that the reservoir was quite turbid in March and observed moderate surface concentrations of algae in July.

Other investigators of Lake Britton assess the trophic state as mesotrophic, but turbidity is noted as a problem along with phytoplankton growth due to biostimulants (Johns, 1975).

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* Trophic assessment is based on levels of nutrients, dissolved oxygen, and chlorophyll a; phytoplankton kinds and numbers; and transparency (Allum et al., 1977).

** See Appendix A.

B. Rate-Limiting Nutrient:

The algal assay results indicate that Lake Britton was nitrogen limited at the times samples were collected (03/26/75 and 11/03/75). The reservoir data indicate nitrogen limitation at all sampling stations and times. However, the low Secchi disc transparencies in March indicate that at times the reservoir may be light-limited due to the turbidity noted above.

C. Nutrient Controllability:

1. Point-sources--During the sampling year, point sources accounted for only 1.3% of the total phosphorus input to Lake Britton. The Crystal Lake Fish Hatchery contributed essentially all of this load; the effluent phosphorus load of the Pit River Hatchery was negligible in comparison to the load measured in the influent. Septic tanks serving shoreline parks and campgrounds were estimated to have contributed less than 0.1% of the total load.

The present phosphorus loading of 43.62 g/m^2/year is over nine times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 15). Although Vollenweider's model may not be applicable to water bodies with short hydraulic retention times, the high phosphorus concentrations in the reservoir indicate the present loading is excessive.

2. Non-point sources--Non-point sources contributed 98.7% of the total phosphorus load during the sampling year. The Pit River contributed 71.4%, Hat Creek contributed 23.3%, and two other gaged tributaries collectively contributed 3.6%. The ungaged minor tributaries and immediate drainage contributed an estimated 0.4%.

The phosphorus export rate of Hat Creek, 55 kg/km^2/year, is significantly higher than the rates of the other gaged tributaries (see page 14). This may be indicative of unknown point sources, underestimation of the point source loads mentioned above, or the impact of irrigation return flows. In another report, it is noted that about 33,650 hectares in the drainage basin are irrigated with water diverted from the tributaries of this lake (Anonymous, 1975). Additional investigation is needed to determine the significance and controllability of nutrients from such non-point sources in the drainage basin.

II. RESERVOIR AND DRAINAGE BASIN CHARACTERISTICS†

A. Morphometry††:

1. Surface area: 5.12 kilometers^2.
2. Mean depth: 9.8 meters.
3. Maximum depth: 36.6 meters.
4. Volume: 50.100 x 10^6 m^3.
5. Mean hydraulic retention time: 6 days (based on outflow).

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean Flow (m^3/sec)*
Pit River	10,328.9	66.54
Clark Creek	50.2	1.08
Burney Creek	471.4	5.86
Hat Creek	942.8	23.22
Minor tributaries & immediate drainage -	131.1	0.82
Totals	11,924.4	97.52

2. Outlet -

Pit River	11,929.5**	94.47

C. Precipitation***:

1. Year of sampling: 94.8 centimeters.
2. Mean annual: 90.2 centimeters.

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† Table of metric equivalents--Appendix B.
†† Dendy, 1974.
* For limits of accuracy, see Working Paper No. 175, "... Survey Methods, 1973-1976".
** Includes area of reservoir.
*** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

Lake Britton was sampled three times during the open-water season of 1975 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at three stations on the reservoir (see map, page v). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first and last visits, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 23.8 meters at station 1, 13.7 meters at station 2, and 8.5 meters at station 3.

The sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR LAKE BRITTON
STORET CODE 0603

PARAMETER	1ST SAMPLING (3/26/75) 3 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (7/14/75) 3 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (11/ 3/75) 3 SITES RANGE	MEAN	MEDIAN
TEMP (C)	6.2 - 7.1	6.5	6.5	11.6 - 22.1	18.0	18.6	10.9 - 12.7	11.9	11.9
DISS OXY (MG/L)	10.0 - 10.8	10.4	10.4	3.8 - 13.8	9.2	9.4	9.6 - 10.6	10.0	10.0
CNDCTVY (MCROMO)	127. - 393.	232.	214.	108. - 150.	134.	137.	73. - 103.	95.	97.
PH (STAND UNITS)	8.1 - 8.8	8.4	8.5	7.4 - 9.3	8.7	8.8	7.9 - 8.2	8.1	8.1
TOT ALK (MG/L)	50. - 72.	65.	66.	69. - 89.	76.	76.	67. - 80.	77.	78.
TOT P (MG/L)	0.051 - 0.097	0.084	0.085	0.057 - 0.162	0.073	0.064	0.061 - 0.077	0.066	0.066
ORTHO P (MG/L)	0.025 - 0.064	0.050	0.050	0.011 - 0.131	0.042	0.040	0.039 - 0.051	0.046	0.047
NO2+NO3 (MG/L)	0.090 - 0.120	0.111	0.110	0.020 - 0.210	0.043	0.020	0.060 - 0.100	0.083	0.080
AMMONIA (MG/L)	0.040 - 0.070	0.049	0.050	0.020 - 0.070	0.028	0.020	0.020 - 0.020	0.020	0.020
KJEL N (MG/L)	0.200 - 0.600	0.343	0.300	0.200 - 0.700	0.333	0.300	0.200 - 0.200	0.200	0.200
INORGN (MG/L)	0.130 - 0.180	0.160	0.160	0.040 - 0.280	0.071	0.040	0.080 - 0.120	0.103	0.100
TOTAL N (MG/L)	0.310 - 0.710	0.454	0.415	0.220 - 0.720	0.376	0.340	0.260 - 0.300	0.283	0.280
CHLRPYL A (UG/L)	1.6 - 1.9	1.8	1.8	4.2 - 12.2	9.1	10.8	2.3 - 5.0	3.6	3.5
SECCHI (METERS)	0.3 - 0.6	0.4	0.5	------ ----------			1.9 - 2.3	2.2	2.3

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
03/26/75	1. Centric diatoms	189
	2. Chroomonas (?) sp.	54
	Total	243
07/14/75	1. Melosira sp.	1,000
	2. Anabaena sp.	437
	3. Synedra sp.	219
	4. Fragilaria sp.	125
	5. Chroomonas (?) sp.	125
	Other genera	187
	Total	2,093
11/03/75	1. Fragilaria sp.	138
	2. Oocystis sp.	79
	3. Chaetoceros sp.	39
	4. Chroomonas (?) sp.	39
	5. Cryptomonas sp.	20
	Total	315

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
03/26/75	1	1.6
	2	1.8
	3	1.9
07/14/75	1	10.8
	2	12.2
	3	4.2
11/03/75	1	5.0
	2	3.5
	3	2.3

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

a. March sample -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.055	0.195	7.6
0.050 P	0.105	0.195	7.9
0.050 P + 1.0 N	0.105	1.195	45.8
1.0 N	0.055	1.195	32.6

b. November sample -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.040	0.105	6.2
0.050 P	0.090	0.105	6.0
0.050 P + 1.0 N	0.090	1.105	12.6
1.0 N	0.040	1.105	27.2

3. Discussion -

The control yields of the assay alga, Selenastrum capricornutum, indicate that the potential primary productivity of Lake Britton was high at the times the samples were collected (03/26/75 and 11/03/75). Also in both assays, the lack of increase in yield with the addition of phosphorus until nitrogen was also added in combination indicates that the reservoir was limited by nitrogen at those times. Note that the addition of nitrogen alone resulted in yields significantly greater than those of the controls.

The reservoir data also indicate nitrogen limitation. The mean inorganic nitrogen/orthophosphorus ratios were 4/1 or less at all sampling stations and times, and nitrogen limitation would be expected.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the California National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page vi). Sampling was begun in November, 1974, and was completed in October, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the California District Office of the U.S. Geological Survey for the tributary sites nearest the reservoir.

In this report, nutrient loads for sampled tributaries were calculated using mean annual concentrations and mean annual flows. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the mean concentrations in Clark Creek at station B-1 and the mean annual ZZ flow.

Nutrient loads for the Crystal Lake and Pit River fish hatcheries were calculated using mean nutrient concentrations and flows given in previous reports (Day, 1972a & 1972b).

No known municipal or industrial wastewater treatment plants impacted Lake Britton during the sampling year.

A. Waste Sources:

1. Known municipal - None

2. Known industrial - None

3. Fish hatcheries* -

Name	Treatment	Mean Flow** (m^3/d)	Receiving Water
Crystal Lake	none	62,394.6	Baum Lake/Hat Creek
Pit River	none	92,980.2	Pit River

* Day, 1972 and 1972b.
** Outflow assumed to be equal to inflow.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Pit River	159,480	71.4
Clark Creek	1,125	0.5
Burney Creek	6,840	3.1
Hat Creek	51,960	23.3
b. Minor tributaries & immediate drainage (non-point load) -	855	0.4
c. Known minicipal STP's - None	-	-
d. Septic tanks* -	5	<0.1
e. Known industrial - None	-	-
f. Fish hatcheries -		
Crystal Lake	2,960	1.3
Pit River	**	-
g. Direct precipitation*** -	90	<0.1
Total	233,315	100.0

2. Outputs -

Reservoir outlet - Pit River 226,420

3. Net annual P loss - 3,105 kg.

* Estimate based on one shoreline park and two campgrounds; see Working Paper No. 175.
** Negligible load.
*** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Pit River	1,884,155	8.2
Clark Creek	11,580	0.5
Burney Creek	184,800	7.7
Hat Creek	304,915	12.6
b. Minor tributaries & immediate drainage (non-point load) -	8,790	0.4
c. Known minicipal STP's - None	-	-
d. Septic tanks* -	175	<0.1
e. Known industrial - None	-	-
f. Fish hatcheries -		
Crystal Lake	4,100	0.2
Pit River	4,410	0.2
g. Direct precipitation** -	5,530	0.2
Total	2,408,455	100.0

2. Outputs -

Reservoir outlet - Pit River 2,454,865

3. Net annual N loss - 46,410 kg.

* Estimate based on one shoreline park and two campgrounds; see Working Paper No. 175.
** See Working Paper No. 175.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km^2/yr	kg N/km^2/yr
Pit River	15	182
Clark Creek	22	231
Burney Creek	15	392
Hat Creek	55	323

E. Mean Nutrient Concentrations in Ungaged Stream:

Tributary	Mean Total P Conc. (mg/l)	Mean Total N Conc. (mg/l)
Clayton Creek	0.022	1.150

F. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	43.62	loss*	470.4	loss*

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Lake Britton:

"Dangerous" (eutrophic loading)	4.60
"Permissible" (oligotrophic loading)	2.30

* There was an apparent loss of nutrients during the sampling year. This may have been due to solubilization of previously sedimented nutrients, recharge with nutrient-rich ground water, unsampled point sources discharging directly to the reservoir, or (probably) insufficient outlet sampling in relation to the short hydraulic retention time.

V. LITERATURE REVIEWED

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VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
0601	AMADOR RESERVOIR	0.040	0.390	408.667	22.383	14.600	0.020
0602	BOCA LAKE	0.012	0.040	372.833	1.700	6.800	0.003
0603	LAKE BRITTON	0.067	0.115	448.500	4.811	11.200	0.047
0604	CASITAS RESERVOIR	0.029	0.050	400.250	3.192	14.000	0.014
0605	CROWLEY LAKE	0.046	0.045	374.750	5.800	12.200	0.034
0606	DON PEDRO RESERVOIR	0.013	0.060	381.733	3.564	11.400	0.004
0607	LAKE ELSINORE	0.469	0.120	489.214	70.572	8.000	0.092
0608	FALLEN LEAF RESERVOIR	0.007	0.040	24.357	0.786	8.800	0.005
0609	LAKE HENNESSEY	0.027	0.060	416.000	4.525	15.000	0.012
0610	LAKE HENSHAW	0.138	0.070	461.000	26.783	9.800	0.073
0611	IRON GATE RESERVOIR	0.184	0.690	440.333	6.217	13.800	0.124
0614	LOPEZ LAKE	0.371	0.090	372.000	8.658	15.000	0.343
0615	LAKE MARY	0.010	0.040	296.000	2.550	10.600	0.002
0616	LAKE MENDOCINO	0.023	0.050	436.500	3.100	9.400	0.008
0617	NICASIO RESERVOIR	0.055	0.345	482.778	6.633	9.800	0.013
0618	LOWER OTAY RESERVOIR	0.058	0.180	447.250	15.933	15.000	0.013
0619	LAKE PILLSBURY	0.022	0.060	466.667	6.389	8.200	0.008
0620	SANTA MARGARITA LAKE	0.037	0.070	400.000	9.122	14.800	0.014
0621	SHASTA LAKE	0.021	0.060	381.542	4.087	9.000	0.015
0622	SHAVER	0.014	0.060	346.400	1.700	7.400	0.004
0623	SILVER LAKE	0.012	0.055	356.000	1.800	7.000	0.003
0624	TULLOCK RESERVOIR	0.025	0.060	433.000	13.878	7.400	0.009
0625	UPPER TWIN LAKES	0.015	0.040	300.200	3.340	7.400	0.004
0626	LOWER TWIN LAKES	0.014	0.040	248.000	2.900	11.400	0.003

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
0601	AMADOR RESERVOIR	35 (8)	4 (1)	43 (10)	9 (2)	17 (4)	26 (6)	134
0602	BOCA LAKE	89 (20)	98 (22)	70 (16)	91 (21)	100 (23)	91 (20)	539
0603	LAKE BRITTON	17 (4)	22 (5)	17 (4)	48 (11)	43 (10)	17 (4)	164
0604	CASITAS RESERVOIR	43 (10)	74 (17)	48 (11)	70 (16)	22 (5)	37 (8)	294
0605	CROWLEY LAKE	30 (7)	78 (18)	65 (15)	43 (10)	30 (7)	22 (5)	268
0606	DON PEDRO RESERVOIR	83 (19)	54 (11)	57 (13)	61 (14)	37 (8)	78 (17)	370
0607	LAKE ELSINORE	0 (0)	17 (4)	0 (0)	0 (0)	78 (18)	9 (2)	104
0608	FALLEN LEAF RESERVOIR	100 (23)	87 (19)	100 (23)	100 (23)	70 (16)	70 (16)	527
0609	LAKE HENNESSEY	48 (11)	54 (11)	39 (9)	52 (12)	4 (0)	52 (12)	249
0610	LAKE HENSHAW	13 (3)	33 (7)	13 (3)	4 (1)	54 (12)	13 (3)	130
0611	IRON GATE RESERVOIR	9 (2)	0 (0)	26 (6)	39 (9)	26 (6)	4 (1)	104
0614	LOPEZ LAKE	4 (1)	26 (6)	74 (17)	26 (6)	4 (0)	0 (0)	134
0615	LAKE MARY	96 (22)	87 (19)	91 (21)	83 (19)	48 (11)	100 (23)	505
0616	LAKE MENDOCINO	65 (15)	70 (16)	30 (7)	74 (17)	61 (14)	63 (14)	363
0617	NICASIO RESERVOIR	26 (6)	9 (2)	4 (1)	30 (7)	54 (12)	46 (10)	169
0618	LOWER OTAY RESERVOIR	22 (5)	13 (3)	22 (5)	13 (3)	4 (0)	46 (10)	120
0619	LAKE PILLSBURY	57 (13)	41 (9)	9 (2)	35 (8)	74 (17)	63 (14)	279
0620	SANTA MARGARITA LAKE	39 (9)	33 (7)	52 (12)	22 (5)	13 (3)	37 (8)	196
0621	SHASTA LAKE	61 (14)	54 (11)	61 (14)	57 (13)	65 (15)	30 (7)	328
0622	SHAVER	78 (18)	41 (9)	83 (19)	96 (22)	87 (19)	78 (17)	463
0623	SILVER LAKE	89 (20)	65 (15)	78 (18)	87 (20)	96 (22)	91 (20)	506
0624	TULLOCK RESERVOIR	52 (12)	54 (11)	35 (8)	17 (4)	87 (19)	57 (13)	302
0625	UPPER TWIN LAKES	70 (16)	98 (22)	87 (20)	65 (15)	87 (19)	78 (17)	485
0626	LOWER TWIN LAKES	74 (17)	87 (19)	96 (22)	78 (18)	37 (8)	91 (20)	463

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	0602	BOCA LAKE	539
2	0608	FALLEN LEAF RESERVOIR	527
3	0623	SILVER LAKE	506
4	0615	LAKE MARY	505
5	0625	UPPER TWIN LAKES	485
6	0626	LOWER TWIN LAKES	463
7	0622	SHAVER	463
8	0606	DON PEDRO RESERVOIR	370
9	0616	LAKE MENDOCINO	363
10	0621	SHASTA LAKE	328
11	0624	TULLOCK RESERVOIR	302
12	0604	CASITAS RESERVOIR	294
13	0619	LAKE PILLSBURY	279
14	0605	CROWLEY LAKE	268
15	0609	LAKE HENNESSEY	249
16	0620	SANTA MARGARITA LAKE	196
17	0617	NICASIO RESERVOIR	169
18	0603	LAKE BRITTON	164
19	0614	LOPEZ LAKE	134
20	0601	AMADOR RESERVOIR	134
21	0610	LAKE HENSHAW	130
22	0618	LOWER OTAY RESERVOIR	120
23	0607	LAKE ELSINORE	104
24	0611	IRON GATE RESERVOIR	104

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 - cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR CALIFORNIA 08/17/77

LAKE CODE 0603 LAKE BRITTON

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 11929.5

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
0603A1	11929.5	158.29	113.55	137.62	128.84	99.39	75.32	63.15	54.09	63.71	73.91	77.02	89.48	94.47
0603A2	10328.9	261.18	62.25	71.94	77.10	37.07	21.43	19.55	22.83	24.87	35.03	73.82	88.83	66.54
0603B1	50.2	2.13	1.44	2.38	2.13	2.13	0.52	0.17	0.11	0.10	0.52	0.55	0.75	1.08
0603C1	471.4	23.38	5.18	5.52	6.01	3.62	2.28	1.98	2.18	2.01	2.82	7.09	8.00	5.86
0603D1	942.8	23.01	21.28	21.28	22.22	29.72	31.98	24.20	21.14	20.60	20.21	22.47	20.49	23.22
0603ZZ	131.1	2.32	1.10	1.45	1.41	1.08	0.43	0.19	0.14	0.13	0.18	0.62	0.82	0.82

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 11929.5
SUM OF SUB-DRAINAGE AREAS = 11924.4

TOTAL FLOW IN = 1167.33
TOTAL FLOW OUT = 1134.37

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
0603A1	11	74	78.438	16	73.057				
	12	74	73.624	16	74.756				
	1	75	74.190	18	38.511				
	2	75	105.055						
	3	75	139.602	23	137.054				
	4	75	138.469						
	5	75	132.240	3	138.753				
	6	75	84.667						
	7	75	66.261						
	8	75	61.731	1	83.818				
	9	75	67.394						
	10	75	77.305	4	92.030				
0603A2	11	74	49.554	16	51.820				
	12	74	47.289	16	50.121				
	1	75	46.440	18	51.537				
	2	75	80.420	8	47.006				
	3	75	108.454	29	93.162				
	4	75	107.321						
	5	75	105.055	3	95.711				
	6	75	58.616						
	7	75	40.776						
	8	75	42.475	1	45.024				
	9	75	45.024						
	10	75	48.705	4	48.988				

TRIBUTARY FLOW INFORMATION FOR CALIFORNIA 08/17/77

LAKE CODE 0603 LAKE BRITTON

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
060381	11	74	0.198	16	0.164				
	12	74	0.212	16	0.184				
	1	75	0.207	18	0.184				
	2	75	1.019	8	0.538				
	3	75	1.954	29	1.982				
	4	75	1.614						
	5	75	3.285	3	4.814				
	6	75	0.793						
	7	75	0.195						
	8	75	0.116	1	0.144				
	9	75	0.102						
	10	75	0.110	4	0.269				
0603C1	11	74	4.134	16	3.540				
	12	74	3.710	16	3.200				
	1	75	3.625	18	3.200				
	2	75	5.833	8	4.672				
	3	75	7.249	29	7.391				
	4	75	7.277						
	5	75	8.891	3	11.270				
	6	75	5.437						
	7	75	3.568						
	8	75	3.540	1	4.191				
	9	75	3.171						
	10	75	3.426	4	3.823				
0603D1	11	74	22.229	16	22.795				
	12	74	23.418	16	23.786				
	1	75	22.880	18	22.795				
	2	75	23.305	8	23.305				
	3	75	25.315	29	25.230				
	4	75	24.919						
	5	75	19.397	3	24.692				
	6	75	22.710						
	7	75	21.804						
	8	75	21.323	1	21.464				
	9	75	21.521						
	10	75	24.268	4	20.926				
060322	11	74	0.510						
	12	74	0.538						
	1	75	0.510						
	2	75	1.756						
	3	75	2.718						
	4	75	2.435						
	5	75	3.794						
	6	75	1.472						
	7	75	0.481						
	8	75	0.311						
	9	75	0.283						
	10	75	0.311						

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 76/09/24

060301
41 01 18.0 121 40 02.0 3
LAKE BRITTON
06089 CALIFORNIA
140991

11EPALES 2111202
0080 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
75/03/26	14 00	0000	7.1	10.4	19	380	8.80	64	0.070	0.600	0.110	0.047
	14 00	0005	7.0	10.3		127	8.10	63	0.040	0.300	0.110	0.052
	14 00	0015	6.7	10.0		393	8.60	64	0.050	0.300	0.120	0.060
	14 00	0045	6.6	10.2		243	8.45	66	0.060	0.200	0.120	0.046
	14 00	0075	6.5	10.4		295	8.60	67	0.060	0.200	0.120	0.037
75/07/14	11 10	0000	21.1	7.4		137	9.30	75	0.020	0.500	0.020K	0.011
	11 10	0005	20.5	10.6		142	9.20	78	0.020	0.500	0.020K	0.015
	11 10	0010	19.1	9.8		138	8.80	89	0.020K	0.300	0.040	0.039
	11 10	0021	12.4	8.8		136	8.65	80	0.030	0.400	0.030	0.047
	11 10	0040	14.4	9.2		119	8.45	69	0.040	0.200	0.090	0.043
	11 10	0078	11.6	3.8		108	7.40	73	0.070	0.300	0.210	0.131
75/11/03	13 40	0000	12.1	10.4	76	103	8.10	80	0.020K	0.200K	0.070	0.045
	13 40	0005	11.9	9.8		99	8.10	78	0.020K	0.200K	0.080	0.047
	13 40	0017	11.9	9.8		99	8.00	78	0.020K	0.200K	0.080	0.048
	13 40	0040	11.7	9.8		97	8.00	78	0.020	0.200K	0.100	0.049
	13 40	0072	11.2	9.6		81	7.90	67	0.020	0.200	0.100	0.039

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/09/24

060301
41 01 18.0 121 40 02.0 3
LAKE BRITTON
06089 CALIFORNIA
140991

11EPALES 2111202
0080 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/03/26	14 00	0000	0.084	1.6	
	14 00	0005	0.077		
	14 00	0015	0.087		
	14 00	0045	0.085		
	14 00	0075	0.092		
75/07/14	11 10	0000	0.064	10.8	
	11 10	0005	0.060		
	11 10	0010	0.062		
	11 10	0021	0.064		
	11 10	0040	0.057		
	11 10	0078	0.162		
75/11/03	13 40	0000	0.067	5.0	
	13 40	0005	0.068		
	13 40	0017	0.066		
	13 40	0040	0.067		
	13 40	0072	0.062		

STORET RETRIEVAL DATE 76/09/24

060302
41 01 40.0 121 39 30.0 3
LAKE BRITTON
06089 CALIFORNIA
140991

11EPALES 2111202
0049 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
75/03/26	14 35	0000	6.2	10.8	22	204	8.70	52	0.060	0.500	0.090	0.054
	14 35	0005	6.2	10.8		225	8.55	50	0.040	0.300	0.090	0.025
	14 35	0015	6.6	10.4		334	8.85	66	0.040	0.300	0.110	0.047
	14 35	0030	6.5	10.5		137	8.20	64	0.040	0.300	0.110	0.054
	14 35	0045	6.4	10.6		134	8.10	66	0.050	0.400	0.110	0.049
75/07/14	10 45	0000	22.1	13.8		150	9.25	74	0.020	0.700	0.020K	0.017
	10 45	0005	22.1	10.0		137	9.00	76	0.020	0.400	0.020K	0.027
	10 45	0015	18.3	9.6		134	8.80	78	0.020	0.200	0.020K	0.036
	10 45	0022	17.5	8.8		139	8.65	75	0.020K	0.200K	0.020K	0.041
	10 45	0038	15.7	9.6		125	8.65	75	0.040	0.200	0.060	0.039
75/11/03	14 10	0000	12.7	10.6	90	97	8.10	79	0.020K	0.200K	0.060	0.042
	14 10	0005	12.0	10.4		97	8.10	80	0.020K	0.200K	0.060	0.044
	14 10	0019	11.8	9.6		95	8.00	80	0.020K	0.200K	0.080	0.045
	14 10	0036	10.9	10.2		73	8.20	79	0.020K	0.200K	0.060	0.042

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/09/24

060302
41 01 40.0 121 39 30.0 3
LAKE BRITTON
06089 CALIFORNIA
140991

11EPALES 2111202
0049 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/03/26	14	35 0000	0.062	1.8	
	14	35 0005	0.051		
	14	35 0015	0.085		
	14	35 0030	0.085		
	14	35 0045	0.084		
75/07/14	10	45 0000	0.071	12.2	
	10	45 0005	0.064		
	10	45 0015	0.065		
	10	45 0022	0.062		
	10	45 0038	0.057		
75/11/03	14	10 0000	0.064	3.5	
	14	10 0005	0.065		
	14	10 0019	0.061		
	14	10 0036	0.064		

STORET RETRIEVAL DATE 76/09/24

060303
41 00 50.0 121 36 37.0 3
LAKE BRITTON
06089 CALIFORNIA
140991

11EPALES 2111202
0030 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
75/03/26	15 20	0000	6.5	10.6	12	341	8.80	71	0.050	0.500	0.110	0.063
	15 20	0005	6.5	10.7		150	8.20	72	0.040	0.400	0.120	0.057
	15 20	0015	6.5	10.4		146	8.20	70	0.050	0.300	0.120	0.048
	15 20	0026	6.4	10.2		146	8.10	71	0.040	0.200K	0.110	0.064
75/07/14	10 10	0000	19.4	11.0		143	8.80	76	0.030	0.500	0.020K	0.040
	10 10	0005	18.9	9.4		138	8.80	76	0.020K	0.200	0.020K	0.047
	10 10	0015	18.6	8.8		134	8.70	74	0.020	0.200	0.020	0.048
	10 10	0028	18.1	8.0		131	8.50	76	0.030	0.200	0.030	0.054
75/11/03	14 30	0000	12.2	9.6	90	99	8.10	74	0.020K	0.200K	0.100	0.049
	14 30	0005	12.0	10.0		99	8.10	72	0.020K	0.200K	0.100	0.050
	14 30	0019	11.9	10.0		99	8.00	74	0.020K	0.200K	0.100	0.051
	14 30	0025	11.9	10.0		97	8.00	76	0.020K	0.200K	0.090	0.051

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/09/24

060303
41 00 50.0 121 36 37.0 3
LAKE BRITTON
06089 CALIFORNIA
140991

11EPALES 2111202
0030 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/03/26	15 20	0000	0.097	1.9	
	15 20	0005	0.095		
	15 20	0015	0.097		
	15 20	0026	0.096		
75/07/14	10 10	0000	0.080	4.2	
	10 10	0005	0.076		
	10 10	0015	0.075		
	10 10	0028	0.082		
75/11/03	14 30	0000	0.066	2.3	
	14 30	0005	0.067		
	14 30	0019	0.066		
	14 30	0025	0.077		

APPENDIX E

TRIBUTARY DATA

STORET RETRIEVAL DATE 76/09/24

0503A1
41 01 15.0 121 40 30.0 4
PIT RIVER
06 15 PONDOSA
O/LAKE BRITTON 140991
BNK BELO PIT#3 DAM .3 M E OF CAMP SHASTA
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/11/16	14 00		0.184	0.400	0.030	0.065	0.065
74/12/16	14 50		0.208	0.700	0.018	0.070	0.070
75/01/18	11 05		0.175	0.800	0.030		0.070
75/05/03	11 30		0.055	1.900	0.035	0.045	0.110
75/08/01			0.010	0.300	0.015	0.040	0.070
75/10/04	12 30		0.015	0.200	0.010	0.035	0.070

STORET RETRIEVAL DATE 76/09/24

0603A2
40 58 05.0 121 32 45.0 4
PIT RIVER
06 15 BURNEY
T/LAKE BRITTON 140991
RT 299 BRDG 9.8 MI NE OF BURNEY
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/11/16	11 20		0.096	0.100	0.020	0.055	0.060
74/12/16	11 10		0.136	0.400	0.031	0.055	0.065
75/01/18	09 40		0.140	1.100	0.050	0.050	0.060
75/02/08	14 05		0.150	0.850	0.050	0.050	0.080
75/03/29	12 36		0.100	0.700	0.035	0.050	0.090
75/05/03	09 00		0.065	1.600	0.035	0.045	0.120
75/08/01			0.050	0.950	0.015	0.055	0.070
75/10/04	11 10		0.065	0.700	0.030	0.040	0.060

STORET RETRIEVAL DATE 76/09/24

060381
41 02 35.0 121 40 33.0 4
CLARK CREEK
06 15 PONDOSA
T/LAKE BRITTON 140991
BNK 50 FT DWNSTRM FRM BRDG 3 M WSW RT 89
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/11/16	12 40		0.008	0.100	0.050	0.030	0.030
74/12/16	14 00		0.008	0.550	0.015	0.030	0.030
75/01/18	10 20		0.010	1.100	0.030	0.025	0.030
75/02/08	11 40		0.025	0.300	0.020	0.030	0.050
75/03/29	13 40		0.015	0.050K	0.045	0.010	0.020
75/05/03	10 15		0.020		0.020	0.015	
75/08/01			0.005	0.100	0.020	0.010	0.020
75/10/04	12 15		0.010	0.100K	0.015	0.030	0.050

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/09/24

0603C1
41 01 00.0 121 39 05.0 4
BURNEY CREEK
06 15 PONDOSA
T/LAKE BRITTON 140991
FOOT BRDG IN MCARTHUR-BURNEY FLS MEM PRK
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/11/16	12 00		0.112	0.500	0.105	0.030	
74/12/16	13 20		0.104	0.500	0.009	0.030	0.030
75/01/18	10 40		0.095	1.450	0.020	0.025	0.030
75/02/08	12 00		0.065	0.550	0.040	0.025	0.030
75/03/29	13 00		0.035	0.500	0.045	0.010	0.020
75/05/03	12 00		0.055	0.100	0.010	0.020	0.070
75/08/01			0.095	3.000	0.035	0.020	0.040
75/10/04	11 30		0.120	0.700	0.020	0.030	0.040

STORET RETRIEVAL DATE 76/09/24

060301
40 58 35.0 121 33 25.0 4
MAT CREEK
06 15 BURNEY
T/LAKE BRITTON 140991
RT 299 BRDG 9 MI NE OF BURNEY
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/11/16	11 00		0.120	0.100	0.030	0.065	0.065
74/12/16	11 00		0.116	0.100	0.018	0.060	0.070
75/01/18	09 30		0.110	1.150	0.025	0.060	0.070
75/02/08	11 00		0.125	0.650	0.055	0.072	0.082
75/03/29	12 20		0.070	0.200	0.040	0.060	0.060
75/05/03	08 30		0.035	0.050K	0.015	0.055	0.100
75/08/01			0.030	0.300	0.010	0.050	0.070
75/10/04	11 00		0.120	0.100K	0.020	0.055	0.080

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/09/24

0603E1
41 02 40.0 121 37 50.0 4
CLAYTON CREEK
06 15 PONDOSA
T/LAKE BRITTON 140991
HWY 89 BRDG 14 MI N OF BURNEY
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/11/16	12	20	0.008	1.600	0.170	0.010	0.010
74/12/16	13	40	0.008	0.675	0.015	0.010	0.010
75/01/18	10	00	0.005	1.050	0.020	0.005	0.020
75/02/08	11	30	0.060	0.700	0.045	0.010	0.030
75/03/29	13	30	0.015	0.100	0.040	0.005K	0.010K
75/05/03	09	45	0.010	0.150	0.010	0.005	0.040
75/08/01			0.015	4.600	0.080	0.005	0.040
75/10/04	12	00	0.005	0.200	0.020	0.005K	0.020

K VALUE KNOWN TO BE
LESS THAN INDICATED